

# Resistance of *Listeria monocytogenes* to sanitation procedures in a slaughterhouse

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## Abstract

*Listeria monocytogenes* is almost 100 % foodborne pathogen. In the European Union in 2022, out of 2738 confirmed cases of human listeriosis, 1330 resulted in hospitalization and 286 in death. The occurrence of *Listeria* in slaughterhouses and the meat industry is caused by the presence of *Listeria* in the environment and animals, i.e. raw materials, its ability to survive in many adverse conditions, and its retention on poorly designed and/or inadequately cleaned and disinfected equipment. To minimize the occurrence of *Listeria* in the distributed products and the risk to consumers when consuming ready-to-eat food without thermal processing, comprehensive implementation of *Listeria* control measures is necessary. These measures include epidemiological control in live animals before arrival at the slaughterhouse, and in the slaughterhouse a comprehensive approach from the design of equipment that must be able to be easily and completely cleaned and disinfected to prerequisite programmes and a Hazard Analysis Critical Control Point plan that guarantee good methods and practices in cleaning and disinfection, as well as their control.

**Keywords:** *Listeria*, slaughterhouse, sanitation

## Introduction

*Listeria* is a gram-positive rod, 0.5-2 µm long, non-spore-forming, facultative anaerobe and non-encapsulated. Depending on the growth temperature, *Listeria* can also be coccoid and motile, and the optimum growth temperature for *Listeria* is 30-37 °C (Batt, 2014). The genus *Listeria* has 20 species including *L. grayi*, *L. innocua*, *L. ivanovii*, *L. welshimeri*, *L. seeligeri* and *L. monocytogenes* (Nwaiwu, 2020). *L. monocytogenes* is the only species pathogenic for humans, except for rare cases of human infection with *L. ivanovii*, which, along with *L. monocytoge-*

*nes*, is pathogenic for animals. Some bacteria from the genus *Listeria* including *L. monocytogenes* retain the ability to grow even at temperatures of 4 °C, temperature of 60 °C kills it in 30 minutes, and it can survive freezing. *L. monocytogenes* grows in a wide range of pH between 4 and 9.5 and tolerates sodium chloride concentrations up to 10 %, while the minimum water activity required for *Listeria* growth ranges from 0.90 to 0.97 (Batt, 2014).

*L. monocytogenes* can cause septicaemia,

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meningitis, encephalitis, endometritis, and abortion in high risk groups; if infection occurs through the alimentary route, the disease usually begins with symptoms of mild fever several hours or longer after the initial infection. *Listeria* enters through the intestinal epithelium and is able to survive phagocytosis. Risk groups for *Listeria* infection include infants, pregnant women, the elderly, and immunocompromised individuals, while in healthy adults it causes mild, self-limiting febrile gastroenteritis (ECDC, 2024; Sibanda and Buys, 2022).

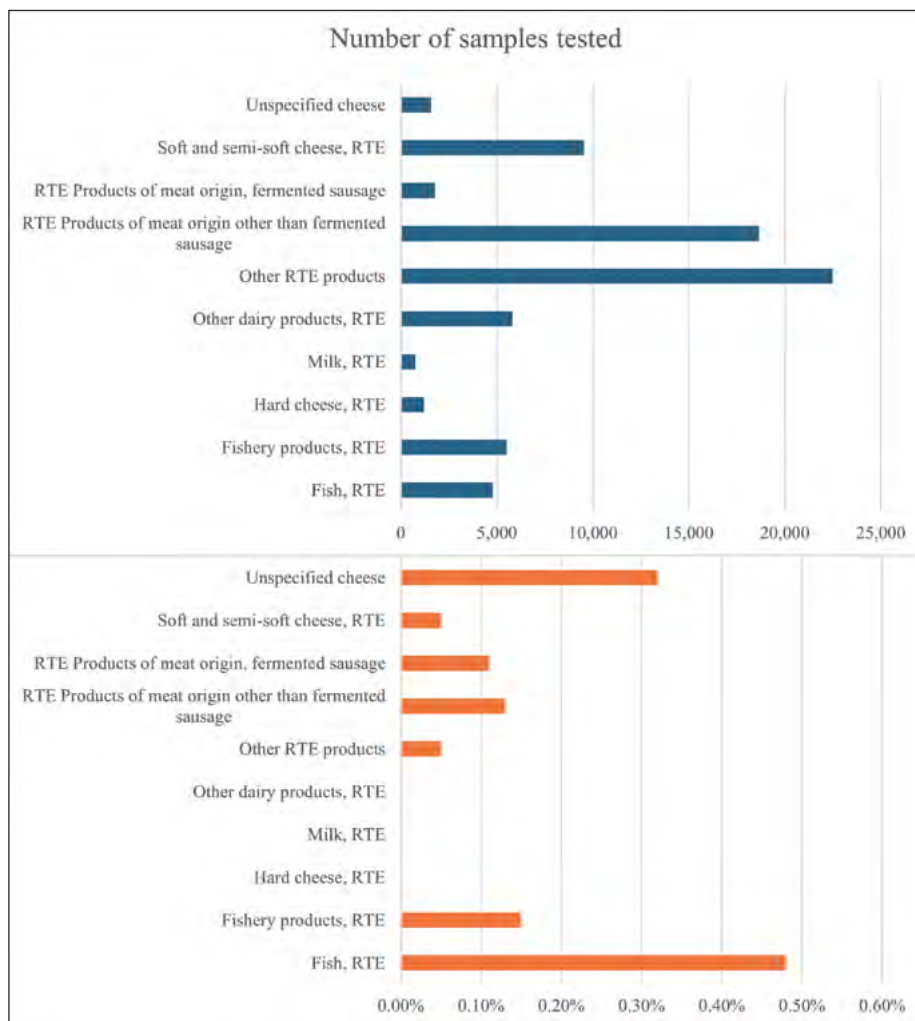
Due to its primary role as an environmental saprophyte, *Listeria* is often found in soil, water and vegetation (Linke et al., 2014). Since the species *L. ivanovii* and *L. monocytogenes* are the only species from the genus *Listeria* that have adapted to the role of pathogens of mammals, their reservoir is also farm animals, which can spread *Listeria* further into

the environment by faecal excretion or by contaminated meat (Esteban et al., 2009).

**The problem of *Listeria monocytogenes* in food**

It is believed that most cases of listeriosis occur through the alimentary route, while some authors suggest that this is 100 % (Monteiro Pires et al., 2020), others still estimate a smaller share of alimentary sources of infection, 88 % (Cressey et al., 2019). The main source of *Listeria* in the food chain are ready-to-eat (RTE) products that have not been heat treated (EFSA and ECDC, 2023). Given the fact that *Listeria* does not survive exposure to a temperature of 60 °C for 30 minutes, alimentary infection with *Listeria* does not occur after ingestion of food that has been thermally processed, unless there has been subsequent contamination (Batt, 2014).

The control of the presence of *Listeria* in



**Graph 1** Number of samples and percentage of positive samples on *Listeria* by food category in distribution in European Union member states for the 2018-2022 period (EFSA and ECDC, 2023)

food is regulated by Commission Regulation No. 2073/2005 on microbiological criteria for foodstuffs (EC, 2005). Due to the previously mentioned specificities of this pathogen such as specific risk groups, the possibility of multiplication at refrigerator temperatures and the effectiveness of heat treatment in eliminating the risk of infection, two criteria for *Listeria* in food are specified in the legal framework. The first, stricter criterion is the absence of *L. monocytogenes* in a 25 gram sample of a product placed on the market during the shelf life and applies to RTE infant foods and RTE foods for special medical needs, the absence criterion in 25 grams also applies to RTE foods that are conducive to the growth of *L. monocytogenes* unless the manufacturer can demonstrate that during the shelf life the number of CFUs of *L. monocytogenes* will not exceed 100 CFU/g, which is the criterion for RTE foods that are not conducive to the growth of *L. monocytogenes*. Ready-to-eat foods that are not conducive to the growth of *L. monocytogenes* are defined by the regulation as products with  $\text{pH} \leq 4.4$  or  $a_w \leq 0.92$ , products with  $\text{pH} \leq 5.0$  and  $a_w \leq 0.94$ , and products with a shelf life of less than five days are automatically classified in this category. Other product categories may also fall into this cate-

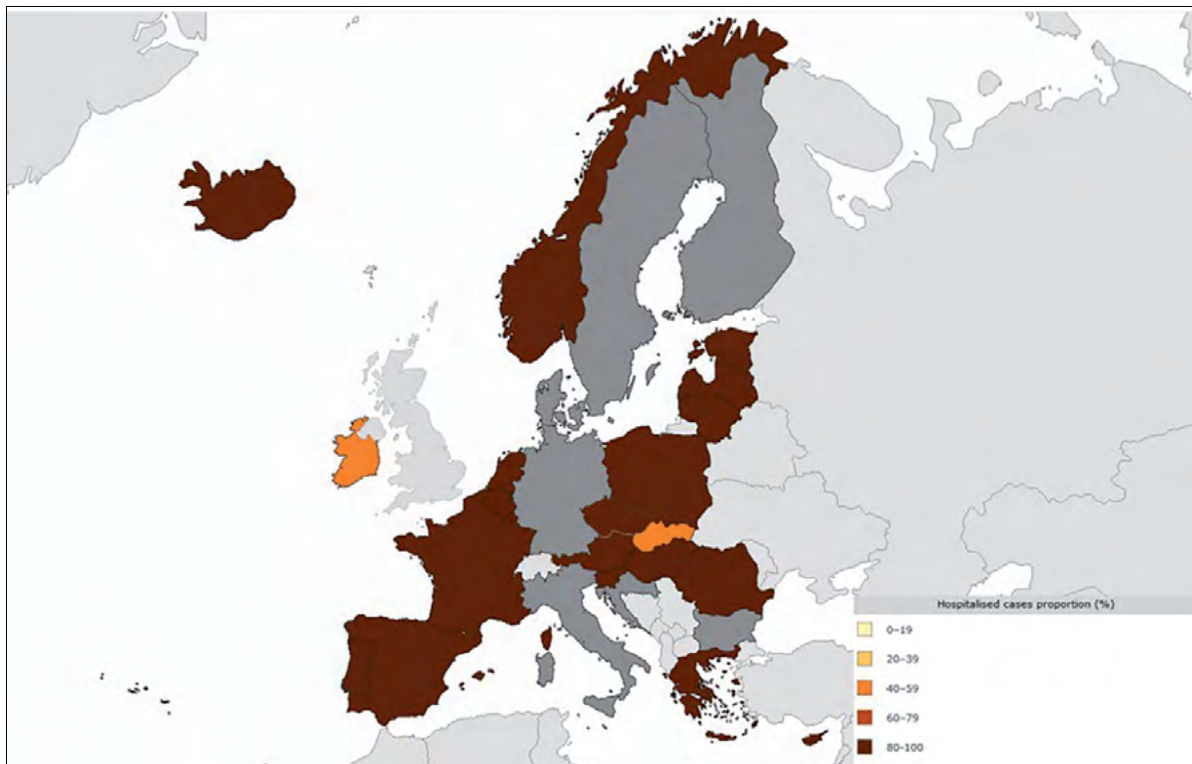
gory, depending on scientific justification (EC, 2005).

Businesses that produce RTE foods that may pose a public health risk due to the presence of *Listeria monocytogenes* shall, as part of their sampling plan, take samples from production areas and equipment to check for the presence of this pathogen (EC, 2005).

### Epidemiology of *Listeria monocytogenes*

The European Food Safety Authority and the European Centre for Disease Prevention and Control state listeriosis as one of the most significant diseases under surveillance in the European Union, with the highest number of hospitalizations and fatal outcomes. In 2022, that number amounted to 2738 cases of listeriosis, of which 1330 ended in hospitalization and 286 in death. Compared to 2021, 2022 saw an increase in reported confirmed cases of human listeriosis by 15.9 %, and the death rate by 13.7 % (EFSA and ECDC, 2023).

Listeriosis, as a disease with a significant risk of hospitalization and death, despite a low rate of reports per 100,000 inhabitants (0.43-0.62), justifies the need for intensive monitoring both at the level of human disease and food as the most common/only source.



**Figure 1** Percentage of hospitalizations of confirmed cases of human listeriosis in the European Union in 2022 (Surveillance atlas of infectious diseases, available at: <http://atlas.ecdc.europa.eu/public/index.aspx>)

**Table 1** Reported confirmed cases of invasive listeriosis in humans and notification rates per 100,000 population by EU/EEA countries for the 2018-2022 period (EFSA and ECDC, 2023)

Country	2018		2019		2020		2021		2022	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
Austria	27	0.31	38	0.43	41	0.46	38	0.43	47	0.52
Belgium	74	0.81	66	0.72	54	0.59	68	0.74	87	0.94
Bulgaria	9	0.13	13	0.19	4	0.06	3	0.04	5	0.07
<b>Croatia</b>	<b>4</b>	<b>0.10</b>	<b>6</b>	<b>0.15</b>	<b>5</b>	<b>0.12</b>	<b>8</b>	<b>0.20</b>	<b>5</b>	<b>0.13</b>
Cyprus	1	0.12	1	0.11	2	0.23	1	0.11	1	0.11
Czech Republic	31	0.29	27	0.25	16	0.15	24	0.22	48	0.46
Denmark	49	0.85	61	1.05	43	0.74	62	1.06	86	1.46
Estonia	27	2.05	21	1.59	3	0.23	5	0.38	11	0.83
Finland	80	1.45	50	0.91	94	1.70	70	1.26	70	1.26
France	338	0.50	373	0.56	334	0.50	435	0.64	451	0.66
Germany	678	0.82	571	0.69	546	0.66	562	0.68	548	0.66
Greece	19	0.18	10	0.09	20	0.19	21	0.20	7	0.07
Hungary	24	0.25	39	0.40	32	0.33	35	0.36	64	0.66
Iceland	2	0.57	4	1.12	4	1.10	5	1.36	2	0.53
Ireland	21	0.43	17	0.35	6	0.12	14	0.28	17	0.34
Italy	178	0.29	202	0.34	155	0.26	230	0.39	345	0.58
Latvia	15	0.78	6	0.31	8	0.42	10	0.53	8	0.43
Liechtenstein	ND	NDA	ND	NDA	ND	NDA	0	0.00	0	0.00
Lithuania	20	0.71	6	0.21	7	0.25	7	0.25	13	0.46
Luxembourg	5	0.83	3	0.49	4	0.64	4	0.63	4	0.62
Malta	1	0.21	5	1.01	5	0.97	0	0.00	1	0.19
Netherlands	69	0.40	103	0.60	90	0.52	86	0.49	94	0.53
Norway	24	0.45	27	0.51	37	0.69	20	0.37	30	0.55
Poland	128	0.34	121	0.32	57	0.15	120	0.32	142	0.38
Portugal	64	0.62	56	0.54	47	0.46	57	0.55	63	0.61
Romania	28	0.14	17	0.09	2	0.01	11	0.06	14	0.07
Slovakia	17	0.31	18	0.33	7	0.13	13	0.24	25	0.46
Slovenia	10	0.48	20	0.96	26	1.24	19	0.90	20	0.95
Spain	370	NDA	504	NDA	191	NDA	355	0.77	437	0.95
Sweden	89	0.88	113	1.10	88	0.85	107	1.03	125	1.20
<b>EU/EEA – (30 countries)</b>	<b>2402</b>	<b>0.51</b>	<b>2498</b>	<b>0.50</b>	<b>1928</b>	<b>0.43</b>	<b>2390</b>	<b>0.53</b>	<b>2770</b>	<b>0.62</b>
United Kingdom	168	0.25	154	0.23	ND	NDA	NA	NA	NA	NA
<b>EU/EEA – (31 countries)</b>	<b>2570</b>	<b>0.47</b>	<b>2652</b>	<b>0.46</b>	<b>1928</b>	<b>0.43</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>

EU – European Union, EEA – European Economic Area  
 ND – no data, NDA – no data available, NA – not applicable

The following three graphs expand on number of samples tested on *Listeria monocytogenes* and positive sample units in all food categories, on positive samples in production and distribution,

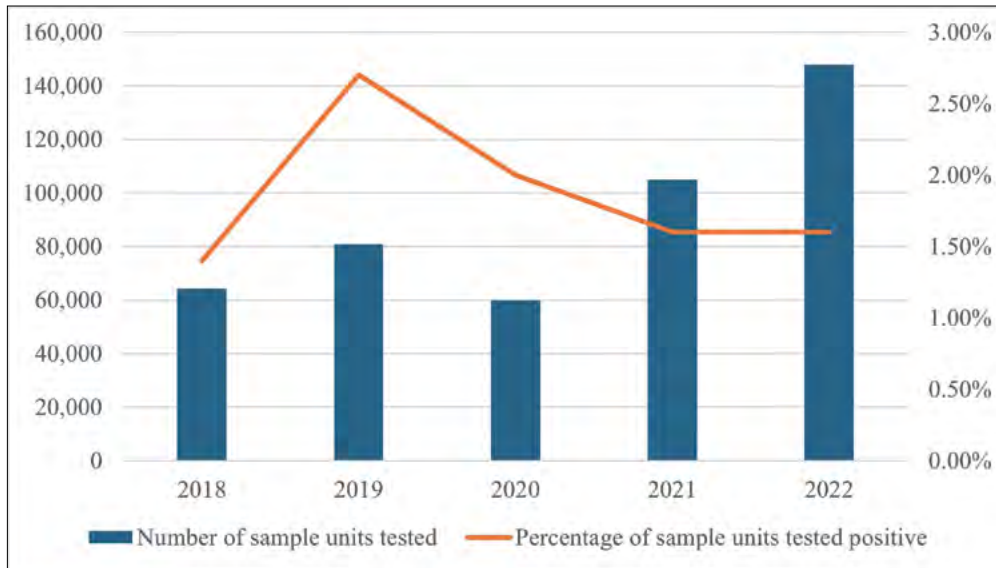
with the first graph showing results of official and unofficial sampling and two last graphs being the results of only official sampling. Giving us a more complete picture of detection rate of *Listeria mono-*

*cytogenes* in food in European Union member states for the 2018-2022 period.

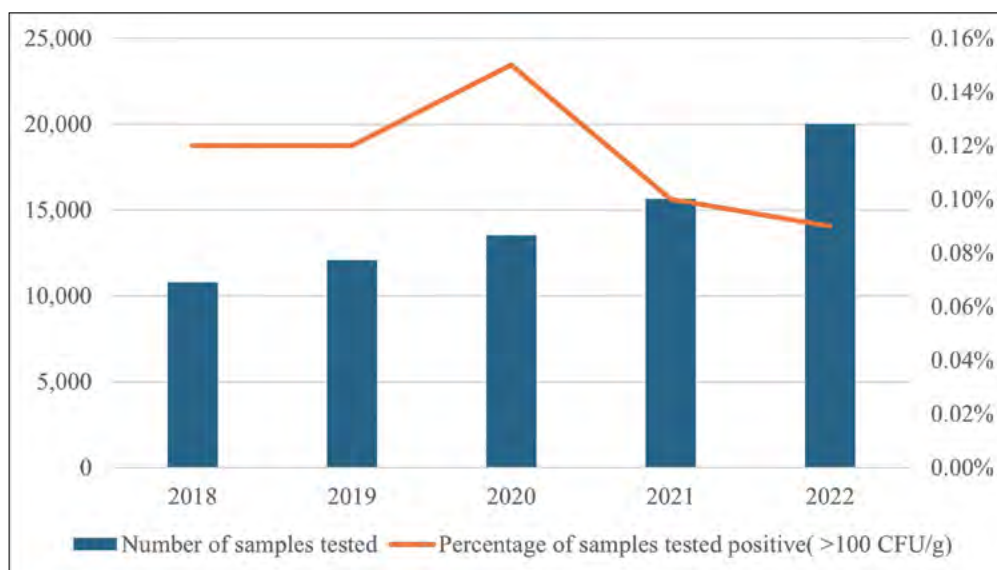
**The problem of the presence of *Listeria monocytogenes* in slaughterhouses**

The presence of *L. monocytogenes* in slaughterhouses poses a significant risk due to the severity of the disease it can cause (ECDC, 2024). The final

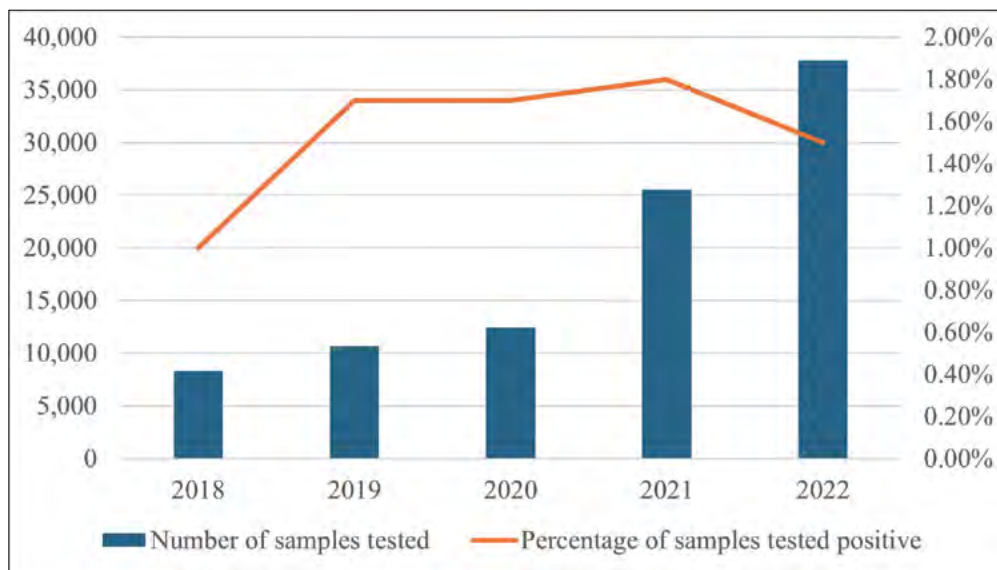
contamination of the product consumed can occur in several ways. Possible sources of the pathogen are the sick animals and their skin, contaminated equipment, biofilm and condensate in the facility (Baskaran et al. 2012; Chmielewski and Frank, 2003; Stoller et al., 2019). If the animal is primarily infected or subsequently contaminated with the pathogen during slaughterhouse processing, such carcass



**Graph 2** The number of tested sample units and the average of sample units positive on *Listeria monocytogenes* in all categories of ready-to-eat food in European Union member states for the 2018-2022 period (Official and industrial sampling) (EFSA and ECDC, 2023)



**Graph 3** The number of tested samples and the average of samples positive on *Listeria monocytogenes* during official production controls in all food categories in European Union member states for the 2018-2022 period (Official and industrial sampling) (EFSA and ECDC, 2023)



**Graph 4** The number of tested samples and the average of samples positive on *Listeria monocytogenes* during official controls in distribution in all food categories in European Union member states for the 2018-2022 period (EFSA and ECDC, 2023)

represents a contaminated raw material that retains its pathogenicity in products that do not undergo heat treatment (Nightingale et al., 2004). Contaminated raw meat can also be a source of infection for the final consumer, despite the fact that heat treatment is necessary and as such kills the pathogen (EFSA and ECDC, 2023). Namely, when the final consumer improperly handles raw meat, e.g. washing meat, using the same utensils for raw meat and food that is not thermally processed, contamination with the pathogen in the environment and food that will not undergo heat treatment occurs (FAO and WHO, 2023; Kassa et al., 2001).

Condensation is a common occurrence in food processing facilities, allowing most bacteria that contaminate it to survive in the slaughterhouse. Dripping from surfaces such as ceilings, pipes and tracks above the slaughter line leads to contamination of the raw material with microorganisms present in the condensate including *Listeria* (Charlton et al., 1990).

Hard-to-reach areas that are poorly cleaned, such as drains and conveyor belts, are also a source of *Listeria* in the facility (Charlton et al., 1990).

Biofilm is a sessile community of microorganisms attached to a substrate, embedded in a self-produced extracellular matrix with phenotypic and genotypic characteristics that enable them to adapt to adverse environmental condi-

tions (Vázquez-Sánchez and Rodríguez-López, 2018). The appearance of biofilm due to poor cleaning and disinfection and failure to remove scale deposits is a persistent source of contamination in the facility. Controlling the appearance of biofilm in facilities and its removal are a key step in *Listeria* control (Chmielewski and Frank, 2003). Stoller et al. (2019) proven the possibility of biofilm production in all (124) strains of *L. monocytogenes* isolated from a processing plant in Switzerland. *Listeria* motility assisted by flagella plays an important role in initial surface attachment and biofilm production, and *L. monocytogenes* mutants without flagella showed poor ability to attach to surfaces and produce biofilm (Lemon et al., 2007). The extracellular matrix of the biofilm contributes to antimicrobial resistance by slowing diffusion and/or chemically reacting with the disinfectant (Simões et al., 2010). Although visual inspection of the object can easily detect heavy soiling, the number of microorganisms does not necessarily correlate with the visual degree of soiling (Kassa et al., 2001). This leads to the need for more complex methods of detecting biofilms and other microbiological plant contamination.

### Prevention measures

Given the environmental prevalence of *Listeria*, its presence in soil, water and vegetation (Linke et al., 2014), prevention starts with the preparati-

on of animal feed. Proper ensiling, rapid achievement of anaerobic conditions, rapid acidification with a final pH between 3.5 and 4.5 prevent the growth of *L. monocytogenes*, as well as other bacteria and moulds that can lead to silage spoilage and toxin production (Gallo et al., 2024; Vilar et al., 2007). Cattle amplify and disperse *L. monocytogenes* into the farm environment through faeces, including strains associated with human disease (Esteban et al., 2009; Nightingale et al., 2004; Rodriguez et al., 2021; Vilar et al., 2007). During the duration of their research, two periods of two weeks and one of five days, Ho et al. (2007) detected faecal excretion of *L. monocytogenes* in 94 % of 32 cows included in the study. The ability of *L. monocytogenes* to enter the viable but non-culturable state gives it an advantage in adaptation, persistence, and transition between different ecological niches (Gião and Keevil, 2014; Lotoux et al., 2022; Tušek et al., 2024). Considering the frequent faecal contamination of the skin of animals going to slaughter, and the consequent contamination of the carcasses, the faecal excretion of *Listeria* represents a significant risk. In order to reduce the risk of contamination of carcasses with *Listeria*, it is necessary to reduce the faecal contamination of animals by improving their rearing conditions, i.e. increasing the amount of litter and reducing the stocking density. When slaughtering animals are soiled with faeces, it is necessary to reduce the speed of the slaughter line and pay special attention during the whole slaughtering process. These procedures do not eliminate the risk of contamination of the carcasses, but they reduce it. For instance, in Finland, by agreeing to additionally charge the costs of processing of dirty animals, which farmers deliver for slaughter, an 85 % reduction in soiling of livestock delivered for slaughter was achieved (Lahti and Soini, 2014). Baskaran et al. (2012) treated cattle skin with octenidine hydrochloride (concentrations 0.025, 0.15, and 0.25 %) and managed to achieve a reduction in the number of *Escherichia coli* O157:H7, *Salmonella* spp., and *Listeria monocytogenes* (>5.0 log CFU/cm<sup>2</sup>) after 5 minutes of treatment at 23 °C.

In addition to prevention on the farm and before animals even enter the slaughtering facility, an important step in the prevention is also planning the construction of the facility and the equipment that will be used in it. Many complicated elements and parts that are difficult to reach and clean, as well as joints and sharp edges create ideal locations for the accumulation of biofilm and the retention of

both *Listeria* and other pathogens (Batt, 2014; Stoller et al. 2019).

### Cleaning and disinfection

Cleaning is the removal of organic and inorganic contamination to obtain a surface free of organic matter and deposits of inorganic matter (limescale). Disinfection is a process that follows cleaning and further removes microorganisms from a surface.

Cleaning process can fall into four categories:

1. Cleaning in place (CIP), equipment is not disassembled at all or minimally, and cleaning solution can circulate;
2. Cleaning out of place (COP), equipment is partially or completely disassembled, and cleaned in containers;
3. Cleaning with foam or gel, which increases contact time with dirt;
4. Manual cleaning, the equipment is completely disassembled and cleaned manually (Keener, 2005; Moerman et al., 2014).

The four most important factors in cleaning are: choosing the right cleaning agent, it should be able to clean the dirt encountered, leave no residue, ideally dissolve limescale deposits and have a disinfecting effect; the time the agent needs to fully demonstrate its effect; the temperature, high enough to dissolve lipid deposits, but not too high so as not to lead to protein coagulation and their adhesion to the surface that is cleaned; and the mechanical force needed to remove the dirt from the surface (Sinner, 1960).



**Figure 2** Sinner's circle, or the balance of four factors essential for cleaning, namely cleaning agent, time, temperature and mechanical force (Sinner, 1960)

The goals of cleaning slaughterhouse facilities are aesthetic and functional, extending the life of the plant and equipment, and ensuring optimal quality and safety of meat (Lutz and Steinberger, 2003). Regulation No 852/2004 on the hygiene of foodstuffs (EC, 2004) encourages food business operators in Article 1 to generally implement procedures based on the principles of the Hazard Analysis Critical Control Point system, together with the application of good hygiene practice. Guides to good production practice and guides to good hygiene practice are to be followed voluntarily by the food business operators. The Codex Alimentarius rules of practice shall be taken into account in the development of national and Community guides to good hygiene practice (FAO and WHO, 2023). The general principles of food hygiene (Codex Alimentarius Code of Practice) sets out general guidelines that the food business operators should adhere to, such as: in areas where food is prepared and stored, cleaning products suitable for contact with food must be used; cleaning and disinfection chemicals must be kept in clearly and accurately labelled containers, if necessary in areas where food is not kept and must be used in accordance with the manufacturer's instructions (appropriate dilutions/concentrations and contact times); suitable and different cleaning equipment should be used for surfaces that do not come into contact with food and surfaces that come into contact with food.

The wet cleaning should include removal of visible dirt, application of an appropriate detergent to loosen soiling, rinsing with water, and if necessary chemical disinfection with rinsing, unless the disinfectant manufacturer states in the instructions that rinsing is not necessary. Proper washing and application of a disinfectant in appropriate concentration for a sufficiently long time according to the manufacturer's instructions ensure the effectiveness of cleaning and disinfection. If washing is not carried out properly and/or the disinfectant is used in sublethal concentrations, microorganisms may survive (FAO and WHO, 2023). Alternating acidic and alkaline solutions during cleaning improves the effectiveness of biofilm removal (Bremer et al., 2006).

Written instructions for the cleaning and disinfection procedures should be used where appropriate and should include: areas, equipment and utensils to be cleaned and where appropriate disinfected; the person responsible for that

task; method and frequency of cleaning and, when appropriate, disinfection; monitoring and verification. Monitoring of cleaning and disinfection effectiveness should be carried out periodically. The parameters monitored to ensure cleaning and disinfection effectiveness may vary and include temperature, pH, concentration of cleaning and disinfectant agents, and microbiological testing (FAO and WHO, 2023). Marriott and Gravani (2006) provide a template for an 11-step procedure for cleaning the slaughterhouse area, which should be carried out daily, and waste should be removed periodically during the process. These steps are as follows:

1. Picking up all large pieces of foreign material and placing them in designated containers;
2. Covering all electrical outlets with plastic protection;
3. Brief pre-rinsing of all surfaces with warm water (50-55 °C) from ceiling to floor, avoiding contact of water with motors, electrical cables and sockets;
4. Applying an alkaline cleaning agent using a centralized or portable foaming device with water at a temperature of 50-55 °C and an exposure time of 20 minutes, the devices must be designed so that it is possible to reach all parts and equipment, although the application of foam requires less work, pressure cleaning systems can more easily reach hidden places where *L. monocytogenes* can be retained;
5. Rinsing in the same order as the pre-rinsing and washing;
6. Inspection all surfaces and equipment and refinishing as necessary;
7. Applying a disinfectant containing at least 50 ppm chlorine to all equipment using a portable or centralized device;
8. Removing, cleaning, and replacing drain covers;
9. Applying white cooking oil to surfaces prone to rust and corrosion; any further use of oil after this is not recommended due to the formation of a protective biofilm that promotes microbial growth;
10. Cleaning all equipment according to manufacturer's instructions;
11. Avoiding contamination during equipment maintenance and setup by requiring workers to carry disinfectant and to disinfect the area after the work is done.

### Checking the effectiveness of cleaning and disinfection

The results of cleaning and disinfection can be checked visually, chemically and microbiologically, and by a combination of these methods (Wirtanen and Salo, 2014).



**Figure 3** Use of foaming agent in a slaughterhouse (Source: Dulikravić, 2019)

Visual inspection of cleanliness is useful when noticing visible soiling, but not when making conclusions about the microbiological cleanliness of visually clean surfaces (Kassa et al., 2001). The advantages of methods such as the ATP and Protein test are the speed of the method, which immediately

enables the implementation of corrective measures, however, these methods, in addition to the detection of microorganisms, also detect other organic residues and have significant deviations from swab cultures. The advantages of classical microbiological examination of surface swabs are the specificity and identification of microbes that contaminate surfaces, however, the disadvantage of this method is its long duration, which prevents the one from taking immediate corrective actions (Moazzami et al., 2023).

### Conclusion

*Listeria* poses a significant public health risk. To control the presence of *L. monocytogenes* in the human population, comprehensive risk control from farm to fork is essential. Proper sanitation and its control affect the elimination of sources of *Listeria* contamination. Elimination of biofilm harbouring the pathogen and smarter design choices of slaughterhouses are determinantal to removing persistent sources of contamination in the facility. With proper methods of testing effectiveness of cleaning and disinfection such as microbiological methods for long term surveillance and fast methods such as ATP and Protein test for fast results complete control of *Listeria* in slaughterhouse can be established.

**Table 2** Advantages and disadvantages of different methods used to check the effectiveness of cleaning and disinfection (Bredholt et al., 1999)

Method	Application	Advantage	Limitation
Contact plate (culture)	Hygiene testing	Identification Selective media Easy to use	Sensitivity Lengthy
Swab (culture)	Hygiene testing	Identification Selective media	Sensitivity Lengthy
Impedance	Hygiene testing, informative, laboratory research	Faster than cultivation Selective media	Sensitivity
Adenosine triphosphate (ATP)	Hygiene testing	<i>In situ</i> ATP-based biofilm detection	Sensitivity
Protein test	Hygiene testing	Fast Easy to use	Only protein-based stains

**Remark:** This paper is an excerpt from the graduation thesis Dulikravić, N. (2024): Resistance of *Listeria monocytogenes* to sanitation procedures in a slaughterhouse, Faculty of Veterinary Medicine, University of Zagreb, Zagreb.

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## Otpornost bakterije *Listeria monocytogenes* na postupke sanitacije u klaoničkom objektu

### Sažetak

*Listeria monocytogenes* je patogen koji gotovo stopostotno inficira alimentarnim putem. U Europskoj uniji u 2022. godini od 2738 potvrđenih slučajeva listerioze 1330 je završilo hospitalizacijom, a 286 smrtnim ishodom. Pojavnost listerije u klaoničkim objektima i mesnoj industriji uzrokovana je njezinom prisutnošću u okolišu i životinjama, odnosno sirovini, zatim sposobnošću preživljavanja u mnogim nepovoljnim uvjetima te zadržavanjem na loše dizajniranoj i/ili neodgovarajuće očišćenju i dezinficiranoj opremi. Kako bi se pojavnost listerije u gotovim proizvodima i rizik za potrošače pri konzumaciji hrane spremne za jelo, bez toplinske obrade, sveli na minimum, potrebna je cjelovita implementacija mjera za suzbijanje listerije. Ove mjere uključuju epidemiološku kontrolu u živim životinjama prije dolaska u klaonicu, a u klaonici cjelovit pristup od dizajna opreme koja se mora moći lako i potpuno očistiti i dezinficirati do preduvjetnih programa i HACCP plana koji garantiraju dobre metode i prakse pri čišćenju i dezinfekciji, kao i njihovu kontrolu

**Ključne riječi:** *Listeria*, klaonica, sanitacija

## Resistenz der Bakterie *Listeria monocytogenes* gegenüber Hygienemaßnahmen in einem Schlachthof

### Zusammenfassung

*Listeria monocytogenes* ist zu fast 100 % ein durch Lebensmittel übertragener Krankheitserreger. In der Europäischen Union führten im Jahr 2022 von 2738 bestätigten Fällen von Listeriose beim Menschen 1330 zu einem Krankenhausaufenthalt und 286 zu einem Todesfall. Das Auftreten von Listerien in Schlachthöfen und in der Fleischindustrie ist auf das Vorhandensein von Listerien in der Umwelt und bei Tieren, d. h. in Rohstoffen, auf ihre Fähigkeit, unter vielen ungünstigen Bedingungen zu überleben, und auf ihr Verbleiben in schlecht konzipierten und/oder unzureichend gereinigten und desinfizierten Anlagen zurückzuführen. Um das Auftreten von Listerien in den vertriebenen Produkten und das Risiko für die Verbraucher beim Verzehr von verzehrfertigen Lebensmitteln ohne thermische Ver-

beutung zu minimieren, sind umfassende Maßnahmen zur Listerienbekämpfung erforderlich. Zu diesen Maßnahmen gehören epidemiologische Kontrollen bei lebenden Tieren vor der Ankunft im Schlachthof, und im Schlachthof ein umfassender Ansatz, der von der Konstruktion der Geräte, die leicht und vollständig gereinigt und desinfiziert werden können müssen, bis hin zu vorgeschriebenen Programmen und einem Plan für kritische Kontrollpunkte (Hazard Analysis Critical Control Point) reicht, die gute Methoden und Praktiken bei der Reinigung und Desinfektion sowie deren Kontrolle gewährleisten.

**Schlüsselwörter:** *Listerien*, Schlachthof, Hygiene

## Resistencia de *Listeria monocytogenes* a los procedimientos de higienización en un matadero

### Resumen

*Listeria monocytogenes* es un patógeno transmitido casi exclusivamente por los alimentos. En la Unión Europea, en 2022, de 2738 casos confirmados de listeriosis humana, 1330 requirieron hospitalización y 286 resultaron en fallecimientos. La presencia de *Listeria* en mataderos y en la industria cárnica se debe a su presencia tanto en el entorno como en los animales, es decir, en la materia prima, así como a su capacidad de sobrevivir en condiciones adversas y de adherirse a superficies mal diseñadas y/o insuficientemente limpiadas y desinfectadas. Para minimizar su presencia en los productos distribuidos y reducir el riesgo para los consumidores al ingerir alimentos listos para el consumo sin tratamiento térmico, es necesaria una implementación integral de medidas de control de *Listeria*. Estas medidas incluyen la vigilancia epidemiológica en animales vivos antes de su ingreso al matadero, y dentro del matadero, un enfoque integral que abarque desde el diseño higiénico de los equipos (que deben permitir una limpieza y desinfección completas) hasta los programas prerrequisitos y un plan de Sistema de Análisis de Riesgos y Puntos Críticos de Control (HACCP), que garanticen buenas prácticas de limpieza, desinfección y verificación.

**Palabras claves:** *Listeria*, matadero, higienización

## Resistenza del batterio *Listeria monocytogenes* alle procedure di sanificazione in un impianto di macellazione

### Riassunto

*Listeria monocytogenes* è un patogeno che infetta quasi esclusivamente per via alimentare. Nell'Unione Europea, nel 2022, su 2738 casi confermati di listeriosi, 1330 hanno comportato il ricovero ospedaliero e 286 si sono conclusi con esito fatale. La presenza della listeria negli impianti di macellazione e nell'industria della carne è causata dalla sua diffusione nell'ambiente e negli animali, ovvero nella materia prima, dalla sua capacità di sopravvivere in molte condizioni sfavorevoli e dalla sua persistenza su attrezzature progettate in modo inadeguato e/o non sufficientemente pulite e disinfettate. Per ridurre al minimo la presenza della listeria nei prodotti finiti e il rischio che comporta il consumo di cibi pronti, per i quali, cioè, non è previsto alcun trattamento termico, è necessaria un'implementazione completa delle misure di controllo e prevenzione della listeria. Queste misure includono il controllo epidemiologico sugli animali vivi prima dell'arrivo al macello, e negli impianti di macellazione stessi un approccio globale che parte dalla progettazione dell'attrezzatura – che deve poter essere pulita e disinfettata facilmente e completamente – fino ai programmi di prerequisiti e al piano HACCP, che garantiscono metodi e pratiche adeguati per la pulizia e la disinfezione, nonché il loro controllo.

**Parole chiave:** *Listeria*, macello, sanificazione